

presented by the intervening space being entirely water, and for the further reason that the Weather Bureau owned and operated cable and land-line connections between the two points, which provided immediate means of checking the results of the work. A number of forms of receivers were devised and tested, and communication between the two stations was accomplished in 1901 by means of a hot-wire receiver or boloscope, and without the use of the "coherer" which Marconi had utilized. During the winter and early spring it gave excellent results and messages were transmitted with a rapidity almost equal to that of the ordinary telegraph. Successful tests were made in the spring of 1902 before representatives of the Army and Navy. It was thought that this receiver would replace all others in use. However, during the summer the atmospheric electric conditions frequently caused the minute platinum loops, on which the action of the boloscope depended, to burn out when connection was made with a vertical wire.

Professor Fessenden developed and patented a number of valuable devices which were used in wireless telegraphy for many years. Unfortunately for the Government, the contract entered into between the Secretary of Agriculture and Professor Fessenden provided that only the Weather Bureau should have free use and right to the latter's patents. The Weather Bureau received no substantial benefits from the patents because it was disengaged from wireless experimentations and transmission activities in 1904, and litigation efforts to secure free use of them by other branches of the Government were unsuccessful.

Professor Fessenden continued his investigations until August 31, 1902, when he resigned. After that date they were continued under the direction of Mr. Alfred H. Thiessen, who had been Professor Fessenden's assistant. Mr. Thiessen's experimental work was transferred to the Pacific coast and wireless stations were established at Point Reyes Light, Calif., and on southeast Farallon Island. Regular communication was established between these points and effectively used in the transmission of weather observations and reports of ships bound for the Golden Gate.

Inter-departmental Board on Wireless Telegraph.—In the meantime the Army and Navy became engaged in wireless telegraph work and investigations. Developments were rapid and it soon became apparent that confusion and unsatisfactory conditions would arise should many Government agencies work independently along the same lines. Under date of June 24, 1904, President Roosevelt appointed Rear Admiral Robley D. Evans, representing the Department of Commerce and Labor; Rear Admiral Henry N. Manney and Lieut. Commander Joseph L. Jayne, representing the Navy Department; Brig. Gen. Adolphus W. Greely, representing the War Department; and Prof. Willis L. Moore, Chief of the Weather Bureau, representing the Department of Agriculture, as a board "to consider the entire question of wireless telegraphy in the service of the National Government," with directions that it submit a full report to him.

The board submitted a unanimous report on July 12, 1904. By order of July 29, 1904, the President directed that "the several departments concerned put its recommendations into effect." Under the terms of the order the Weather Bureau ceased its wireless experiments and operations. Such work was assigned to the Navy on coasts and the Great Lakes, and to the Army in the interior. It provided that "the Navy

Department shall, without charge to the Agricultural Department, receive and promptly transmit to the oceans or to islands, or to other places where the information can be made useful, the storm warnings of the Weather Bureau."

The members of this board, as shown by their report, had such a clear vision of the potentialities of radio communication and of the necessity for its regulation, and were so prophetic of the confused conditions that now confront this country and how to remedy them, that it is quoted in full.

REPORT OF INTER-DEPARTMENTAL BOARD APPOINTED BY PRESIDENT ROOSEVELT.

LIGHTHOUSE BOARD ROOM,
Washington, July 12, 1904.

The board first met in the Lighthouse Board room, in obedience to the order of the President and pursuant to the call of the chairman, at 11 a. m., July 6, 1904. Present, all the members.

The chairman requested Lieutenant Commander Jayne to act as recorder, and then read the letter appointing the board, a copy of which is prefixed and marked "A," and the inclosures, marked "B" to "J," inclusive.

After the reading of the memorandum from the Secretary of Agriculture, marked "D," Professor Moore stated that Mr. Fessenden had, since it was written, made a satisfactory settlement of the claims against him by assigning the patent rights in question to the Department of Agriculture, Weather Bureau.

The board thoroughly discussed and maturely considered the questions before it at its meetings held from time to time, all the members being present at each meeting.

The following was found to be the status regarding Government wireless telegraph stations:

(a) The Department of Commerce and Labor has established no stations, but permission has been granted to other departments to erect 10 on lighthouse reservations and on the Nantucket Shoals Lightship and its relief.

(b) The Army has operated six stations and is preparing to install two others in Alaska. The urgent necessity for the stations in Alaska has caused the temporary removal of the apparatus from two of the first mentioned, but it is in process of replacement. Four other Army stations have been proposed, but for two of these the Chief Signal Officer thinks that the proposed naval stations in the same localities, if available to the Army, would make duplication unnecessary. The Army also has one portable train for use in maneuvers or for other military purposes.

(c) The Department of Agriculture made valuable and extensive experimentation, and has established two stations and contemplated establishing others at prominent points along the coast lines.

(d) The Navy Department has established 20 shore stations. The apparatus has been removed from 1 of these but it will be replaced in a few days. Arrangements are being made for the establishment of 10 more in the near future, a complete equipment, or some portion of it, having been ordered for each one. This includes the 2 lightships that take turns on Nantucket Shoals. In addition to these 30 stations, it is proposed to establish about 50 more on shore and to start on the more important of these at an early date.

The Navy Department has entered into a very important contract for the equipment of long-distance stations at Key West, Guantanamo, points to be determined in Porto Rico and in the Panama Canal Zone, and Pensacola. Satisfactory communication is to be established between all of the first four and between Key West and Pensacola. Communication from any one of these stations to ships at any points between it and a communicating station is also to be established.

Twenty-four naval ships have already been equipped and 10 others are to be equipped immediately, or before the completion of the repairs which they are undergoing. It is proposed to equip 68 others after the report of the board which is now conducting test of various systems has been acted upon, making a total of 102.

One torpedo-boat outfit has been ordered for trial. If this apparatus is successful a number of torpedo-boat destroyers and small gunboats may be equipped, making the total number considerably larger.

With these small vessels provided with wireless apparatus, there would be about 200 naval stations on shore and afloat.

(e) The Treasury Department, while having under consideration wireless installations for the Life Saving Service and the Revenue Marine Service, has established no stations, but has relied on a leased commercial wireless system.

The following was found to be the status of private stations:

The Marconi Co. has a long-distance station on Cape Cod for communicating across the Atlantic, and two others of comparatively short

range on Long Island. The board understands that that company proposes to establish numerous stations along the Atlantic and Pacific coasts.

The New York Herald Co. has a station on the lighthouse reservation on Sankaty Head, Nantucket Island, and has been permitted to maintain stations on the two lightships which relieve each other on Nantucket Shoals. These privileges have been withdrawn, however, owing to the refusal of the Marconi Co., which operated them for the Herald, to receive wireless messages from vessels using other systems.

The American De Forest Wireless Telegraph Co. and the National Electric Signal Co. (Fessenden system) have stations in the vicinity of New York and both propose to establish a chain of them along the coast. The former company has already begun operations at Cape Hatteras and at Key West, and has announced that they propose to establish several stations to bridge the Pacific and make foreign connections. It has also established several stations away from the seacoast, especially on the Great Lakes, and is planning to have a regular interior system, according to one of its officers.

The Fessenden system has stations in Philadelphia and Washington. Fessenden states that his company is negotiating for permission to establish communication with Bermuda.

The Providence Journal maintains several stations in the vicinity of Narragansett Bay and there are several other systems which are at present not very active.

On the Pacific coast the Pacific Wireless Telegraph Co. has several stations and has been making persistent efforts to obtain authority to establish stations on the lighthouse reservations, Farallon Islands, and at other prominent Government reservations along the Pacific coast.

There is an interisland system operated in Hawaii.

A number of trans-Atlantic liners are using the Marconi apparatus. Few coasting vessels are using any system, but the indications are that this method of communication will come into quite common use when the shipowners feel that conditions are favorable.

The Navy Department has at times been very seriously interfered with in the vicinity of New York and Boston and there are already so many stations in the vicinity of Newport that an effort has been made by the officer in charge of the torpedo station to establish a tentative arrangement whereby the various stations will interfere as little as possible with each other.

Reports from the naval wireless station on Cape Cod indicate that on one occasion that station was temporarily crippled, very probably by heavy sending at the Marconi long-distance station a few miles away.

It would appear that the Weather Bureau already has a station at one of the most important points on the Pacific coast, where the Navy Department desires to erect one and equip it with more powerful apparatus than now in use by the Weather Bureau. The Weather Bureau also intended putting in new apparatus, it having been demonstrated that that now in use is unable to communicate with the nearest naval station in San Francisco Bay, although the latter has sufficient power to reach far beyond the Farallons. This is one of the places where the Pacific Wireless Telegraph Co. is so anxious to locate.

The Weather Bureau also contemplated establishing stations at prominent points where the Navy Department already has stations in operation or proposed to establish them. Most of the stations proposed by the wireless telegraph companies are to be located at prominent points where Government stations are already established or proposed. This state of affairs seems to demand prompt action to avoid most unfortunate confusion and unnecessary duplication.

As a first step toward avoiding this condition the board adopted the following resolution:

"Resolved, That all installations of Government wireless telegraph stations be suspended, except at stations now under contract, until the final report of the board is acted upon by the President. That all departments of the Government interested in wireless telegraphy should refuse to allow any private company to install a station on any Government reservation until so authorized by proper authority."

CONCLUSIONS.

The conclusions of the board are:

That the science of wireless telegraphy has been advanced by the able and persistent work of the Signal Corps of the Army and the Weather Bureau of the Department of Agriculture, as well as by the experimental work of the Navy Department;

That wireless telegraphy is of paramount interest to the Government through the Navy Department, and that its use by the Signal Corps of the Army for communication between military posts of the Army and other necessary links will be necessary both in peace and war, and that such use shall be unrestricted. When interference seems probable between stations of the Navy and War Departments, the question involved shall be mutually settled by representatives of the two departments.

That coastwise wireless telegraphy is not a necessity for the work of the Weather Bureau of the Department of Agriculture, provided that the necessary meteorological data for that department can be collected by the stations of the Navy Department from ships at sea and by them sent to the Weather Bureau of the Department of Agriculture.

That the maintenance of a complete coastwise system of wireless telegraphy by the Navy Department is necessary for the efficient and economical management of the fleets of the United States in time of peace and their efficient maneuvering in time of war.

That the best results can be obtained from stations under the jurisdiction of one department of the Government only, and that representatives of more than one department should not be quartered at any station.

And, finally, the board concludes that the Government must take the necessary steps to regulate the establishment of commercial wireless-telegraph stations among the States and between nations.

RECOMMENDATIONS.

In order that the above conclusions may be carried into effect, the board recommends—

That the Signal Corps of the Army be authorized under its chief to establish from time to time such wireless stations as he may deem necessary, and that they do not interfere with the coastwise wireless-telegraph system of the Government under control of the Navy Department; and further, that the Chief Signal Officer be requested to inform the Navy Department what stations of its system may be utilized to transmit messages for the Signal Corps or other bureaus of the War Department, and that representatives of the Signal Corps of the Army and the Bureau of Equipment of the Navy Department be at once requested to draw up such rules as will insure the efficient and harmonious carrying into effect of the above recommendations.

That the necessary steps be taken to have the Weather Bureau of the Department of Agriculture turn over to the Navy Department all coastwise wireless-telegraph apparatus now under its control, and such material as it may have in its possession which can be utilized by the Bureau of Equipment of the Navy Department, and that proper transfers of funds for this purpose be made.

That the Weather Bureau of the Department of Agriculture furnish to the Hydrographic Office of the Navy, and to the naval wireless-telegraph stations, or to other portions of the public service, such meteorological data as it or they may desire at no cost to them.

That the Department of Agriculture shall continue the work of its meteorological vessel-reporting and storm-warning stations, as now constituted and provided for by law, and continue the control of seacoast telegraph systems, except wireless systems.

That the necessary steps be taken that the Navy Department may equip and install a complete coastwise wireless-telegraph system covering the entire coasts of the United States, its insular possessions, and the Canal Zone in Panama.

That the Navy Department be directed to receive from the Signal Corps of the Army, at such points as may be requested by the Chief Signal Officer of the Army, all messages for Army posts within their radii, and transmit them, under such rules as may be agreed upon by the representatives of the Signal Corps and Bureau of Equipment, without cost to the Signal Corps of the Army.

That all meteorological reports from vessels of war or commerce or other sailing craft, now being forwarded direct to the Hydrographic Office of the Navy, shall be forwarded direct to the Weather Bureau, and the control of ocean meteorology be transferred to the Department of Agriculture, which already has ample law for doing this work.

That the estimates for the support of the Hydrographic Office of the Navy, or any other office of the Navy, for the next and succeeding fiscal years, do not contain any provision for the making of ocean forecasts, or for the publication of meteorological data, other than such as may be needed by the hydrographer of the Navy for use of the pilot and other charts, which data shall be furnished by and credited to the Weather Bureau.

That it is the opinion of this board that no meteorological work need or should be done by any portion of the Navy for the purpose of publication, or for the making of forecasts or storm warnings; that all such duties, being purely civil, should devolve upon the Weather Bureau of the Department of Agriculture in accordance with the organic act creating that bureau;

That the wireless stations of the Navy Department shall, without charge to the Agricultural Department, receive and promptly transmit to the ocean or to islands, or to other places where the information can be made useful, the storm warnings of the Weather Bureau;

That the Navy Department shall request all vessels having the use of its wireless stations for the receipt of messages, to take daily meteorological observations of the weather when within communicating range and to transmit such observations to the Weather Bureau, through naval wireless stations, at least once daily, and transmit observations oftener when there is a marked change in the barometer; and that there shall be no charge against the Agricultural Department for these observations, or for the transmission thereof;

That representatives of the Department of Agriculture and the Bureau of Equipment of the Navy Department be directed to prepare the necessary rules for the harmonious and efficient carrying on of the above recommendations.

We recommend that as fast as the naval wireless telegraph stations are put in operation the Navy Department be directed to receive and transmit through these stations, free of charge, all wireless messages to or from ships at sea, provided such stations do not come in competition with commercial stations, until such time as Congress may enact the necessary legislation governing this subject.

In asking for legislation on this point, the board desires to invite attention to the fact that where wireless stations are needed for the merchant marine, as a rule the Navy will also require them. The board believes it to be in the interest not only of governmental, but public economy and efficiency, to permit the naval stations to handle the public service, for the present state of the art but one station is desirable, for the public interests in such places. As the needs of the Navy are paramount on account of the problem of national defense, private stations should not be allowed to locate to the disadvantage of the former. Moreover, there is at present no public need for multiplication of stations at these points.

It is admitted, however, that there may be special cases where private stations can serve a useful purpose, and the board believes that the Department of Commerce and Labor should have the duty of issuing licenses in such cases under such regulations as will prevent interference with stations necessary to the national defense. All private stations in the interior of the country should also be under supervision of the Department of Commerce and Labor.

This method of placing private stations under full Government supervision is desirable in order to regulate them for their mutual and the public welfare, as well as from considerations of national defense. Aside from the necessity of providing rules for the practical operation of such stations, it seems desirable that there should be some wholesome supervision of them to prevent the exploitation of speculative schemes based on a public misconception of the art.

It is believed that invention and private enterprise should be encouraged in every legitimate way, and it is the policy of the Navy Department to do this. It has the means of assisting inventors that no other department has, and it believes that in order for it to lead the navies of the world in this matter, which is of great importance to the national defense, that every reasonable facility should be given inventors, while at the same time it is working out the problems of the application of their inventions to its requirements in times of peace and war.

To prevent the control of wireless telegraphy by monopolies or trusts, the board deems it essential that any legislation on this subject should place the supervision of it in the Department of Commerce and Labor.

Because international questions may arise, due to the fact that the use of wireless-telegraph stations in our own possessions may affect the use of similar stations in foreign countries, it is desirable for the Congress to enact legislation which will enable the Government properly to handle such cases; a failure to do so may seriously embarrass the Government at some future time.

It is thought that the legislation recommended in placing private stations under the supervision of the Department of Commerce and Labor will also cover this case.

In conclusion, the board deems it essential that the Executive take such action as in his judgment seems wise to prevent the erection of private wireless-telegraph stations where they may interfere with the naval or military operations of the Government until legislation may be had by Congress on this subject.

Appended thereto were two extracts from the Revised Statutes, marked "W" and "X," which related to the operation of Government telegraph lines; also a decision of the Supreme Court, marked "Y," and the final protocol of the Preliminary Conference on Wireless Telegraph, held in Berlin in August, 1903, marked "Z."¹

Navy takes up radio work for the Weather Bureau.—In accordance with the provisions of President Roosevelt's order, the Navy Department immediately began to make arrangements to place its facilities in operation for the handling of Weather Bureau business. Under date of November 30, 1904, orders were issued to its radio stations to promptly transmit all weather reports and warnings required by the Weather Bureau, and also directed its ships equipped with wireless apparatus to take and transmit meteorological observations at least once daily on designated schedule and oftener when barometric changes indicated storm conditions. It has continued to do this work in a satisfactory manner and in an excellent spirit of cooperation.

Cooperation with Lighthouse Board.—An immediate development in the use of the naval radio stations was the transmitting of storm warnings to lighthouses and lightships which had radio communication therewith. Cooperation of the Lighthouse Board was secured and arrangements made for the display of storm-warning flags at such lighthouses and lightships. By July 1, 1905, arrangement for radio communication and storm-warning displays at off-shore points had been perfected as follows:

From navy yard, Portsmouth, N. H., to Cape Ann and Thatcher Island, Me.

From torpedo station, Newport, R. I., to Nantucket Shoals Lightship.

From Brooklyn Navy Yard to Highlands of Navesink, N. J.

From Norfolk Navy Yard to Diamond Shoals Lightship.

From Charleston Navy Yard to Charleston Lightship.

From Mare Island Navy Yard to Yuba Buena.

From San Juan Naval Station to Culebra, Panama.

In early succeeding months storm-warning displays were accomplished by the same plan at Cape Elizabeth, Me.; Highland Light; Cape Cod; and Dry Tortugas.

Radio a factor in meteorology.—Radio communication has been an outstanding factor in the developments of meteorology during the past 20 years. It has enabled the Weather Bureau to secure observations from ships at sea and from otherwise inaccessible places, to amplify current synoptic charts used in its forecast work, to reach with its forecasts and warnings places that have no other means of communication, and especially to furnish ships at sea with advices and storm warnings vital to their safety. The functions of the Weather Bureau are such as to require that it keep abreast of radio developments and extensions and to promptly utilize them in every practicable manner.

COLLECTION OF WEATHER DATA BY RADIO.

Weather radiograms from ships at sea.—The first radiogram received by the Weather Bureau containing a weather observation taken on a ship in the Atlantic was from the S. S. *New York*, on December 3, 1905, in latitude 40° N., longitude 60° W. It was the result of arrangements made with the Marconi Telegraph Co. to receive at its station at Siasconset, on Nantucket Island, messages containing weather reports from passenger vessels plying between New York and European ports that were equipped with wireless apparatus. Few reports were received from ships in 1905 and 1906, but sufficient to indicate the great value of and necessity for such observations in forecast work.

In 1906 the vessel weather service was established as a distinct project. The masters of about 50 vessels agreed to take weather observations once daily at a fixed hour when in prescribed ocean areas, and to forward them by radio to the Weather Bureau office in Washington. These vessels were for the most part passenger ships engaged on the New York to Europe routes, although a few operated in the southern Atlantic and in the Gulf of Mexico and one in the Pacific. The latter was the S. S. *President*, which was said to be the only vessel in the Pacific Ocean that carried wireless apparatus at that time. The first observation received from the S. S. *President* was on June 18, 1907. A report from the S. S. *Cartago* on August 26, 1909, when near the coast of Yucatan and at a time that a hurricane was in progress in those waters, was the first ship message that was received and used in connection with the issuance of hurricane warnings.

¹ W and X, section 2, act of Oct. 1, 1890 (26 Stat. 653).

² Supreme Court, term of October, 1886. *Telegraph Company v. Texas*.

³ Report of Preliminary Conference Concerning Wireless Telegraphy. Berlin, Aug. 13, 1903.

The vessel weather service was extended in correspondence with the installation of radio apparatus on ships and in a few years included freight as well as passenger vessels. At the present time there are 93 paid vessel weather stations on the Atlantic side and 23 on the Pacific side. Payment of 50 cents is made for each observation taken and radioed. In addition, a much larger number of vessels belonging to ship corporations, who, in recognition of the great benefit the forecasts, storm and hurricane warnings are to them, do not permit any charges to be made by their employees for taking the observations. Among these cooperating companies are the Shipping Board, the Standard Oil Co., the Texas Co., the Gulf Refining Co., Dodwell & Co., Pacific Mail; and the Texas Oil Co.

It is highly desirable that vessel reports be obtained from all areas in the Atlantic and throughout the year, as they are of inestimable value in the forecasting of storms that affect the trans-Atlantic lanes, the southern Atlantic and Gulf of Mexico, but compensation to observers, the cost of radio ship-to-shore tolls, and the inadequacy of appropriations make it necessary to limit the number of vessel weather stations and the period of their operation.

This development of the vessel weather project is indicated by the fact that in 1906, 738 observations were received, and from only 35 ships. In 1922 more than 15,000 reports were received from over 300 ships. All vessel weather observations are transmitted in a special code provided for that purpose.

Nearly all commercial ships engaged in making weather reports are equipped with radio apparatus owned and operated by one of the several commercial radio companies. Under provisions of a law, applicable only to the Weather Bureau, separate contracts are made with these companies and special rates are secured. These contracts provide that, whenever possible to do so, weather messages shall be sent to the nearest naval radio station, which forwards them by land lines to the forecast center to which they are addressed.

Weather observations from ships at sea are of vital importance. They supplement the reports taken at land stations, enable the forecasters to locate storms and hurricanes over the oceans and to issue accurate forecasts and timely warnings to vessels in the storm areas which are not only necessary to safe navigation but are of great aid in the conduct of the ship work at sea.

Cooperation with Shipping Board.—On January 24, 1921, the Shipping Board issued general instructions that beginning with June 1, 1921, all masters of ships under its control should take and forward to the Weather Bureau daily observations when in prescribed areas. Ships in the Atlantic address their messages to Washington; and those in the Pacific to San Francisco and Honolulu, according to their position. No charge is made for the observation work or for radio charges from ship to shore. This cooperation by the Shipping Board is of inestimable value. It is the only group of vessels of commerce on the Atlantic side that radioes its reports throughout the year. The remainder of the vessels operating in the Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea confine their observations to the hurricane season, June to November, inclusive. Ships in the Pacific report throughout the year.

Obtaining observations by radio from otherwise inaccessible places.—As is well known, local conditions are a minor consideration in the making of weather forecasts for a particular section. Dependence is placed mainly on conditions that prevail in more or less extended areas.

Therefore, it is necessary for successful forecast work that there be available to the forecaster reports of current conditions from widespread areas. Not until observations from the entire Northern Hemisphere are obtained will the ideal be reached.

For some years after the meteorological service of the United States was established, reports were obtained exclusively by telegraph and mainly from places in the States east of the Great Plains. However, the building of the transcontinental railroad lines soon brought practically all of the States into meteorological range. In succeeding years cable connections with a few islands of the West Indies and of the Pacific, and with Alaska, extended the observation areas. But telegraph lines and cables are placed only in regions where commerce justified their existence, and until the advent of radio there appeared to be no prospect of obtaining current reports from the vast ocean areas, islands, and from the far north, from which observations were so much needed. Radio offered a solution of the problem and the Weather Bureau has availed itself of this form of communication to the fullest possible extent. The observation area has been materially extended thereby, but not nearly to the degree that is hoped for and expected during the years to come.

Countries from which daily reports are received by radio.—Daily or twice daily observations now are secured by telegraph and cable from about 240 stations in the United States and Canada (210 in the United States and 30 in Canada), from 17 places in Mexico, 20 points in the West Indies, 12 Alaskan stations, and 22 European cities. These are supplemented by reports obtained wholly or in part by radio from 16 places in the West Indies and Central America; 5 in Alaska; from Honolulu, Guam, and Midway Island, in the Pacific; the Philippines, China, Japan in the Far East, and from 36 places in Europe and the Arctic regions, including the Azores, Greenland, Iceland, Spitzbergen, and Jan Mayen. All of these radio reports are transmitted by United States naval radio stations, except two in Alaska (Nome and Eagle) for which the United States Signal Corps radio service is utilized. The first Alaskan report obtained by radio was from Nome, on November 1, 1907, followed by Eagle on June 24, 1909; Kodiak and Dutch Harbor, May 1, 1915, and St. Paul Island, August 8, 1915.

The Canadian Government is now arranging for the establishment of radio stations at points in the Mackenzie River region primarily for the purpose of obtaining meteorological reports. These will be made available to the United States Weather Bureau. It is highly important that similar radio and meteorological stations be located in the northern section of Alaska.

It is apparent that meteorology will advance hand in hand with radio and that there must be close and undisturbed contact between the agencies engaged in meteorological and radio activities. The crying need of meteorology is more information from ships and from inaccessible places, and especially from the areas in and about the Polar regions. Meteorology is essentially an international science. Weather has no national allegiance. Cyclones and anticyclones pay no attention to boundary lines. Conditions prevailing in one country to-day may affect another to-morrow, or perhaps a week hence. Partial exchange of meteorological reports between the United States, European, and Asiatic countries has existed for many years, but there must be more or less complete exchange of meteorological reports among the nations in the Northern Hemisphere, and in this radio will play a large and important part.

International exchange of Weather Reports.—The United States is now exchanging weather reports with the meteorological services of Canada, Mexico, Cuba, the Bahamas, Japan, China, the Philippines, the Azores, and France (and through France with other European services). Messages containing reports from 32 stations in the United States and Canada are radioed each night to the director of the meteorological service of France, and are immediately broadcast from the Eiffel Tower radio station for the benefit of all countries within its range.

Radio was first used for transmitting this report to France on January 17, 1919, replacing cable service which had been utilized for many years prior thereto. The forwarding of European reports to the United States began August 15, 1922. These are observations taken in the p. m. and supplement a similar group of a. m. reports forwarded by cable from the London to the Canadian meteorological service at Toronto, which are immediately repeated by telegraph to Washington. A daily message is also received from Paris containing observations taken at midnight at 38 places in Europe, embracing England, Spain, Switzerland, Germany, Austria, Czechoslovakia, Poland, Denmark, Norway, and Sweden; also Iceland, Greenland, and the Azores. Plans are under way for similar exchanges with other countries in which radio will be the communicating medium.

Reports from Nassau, Bahama Islands, have been received in exchange for a group of United States reports for a long period. For more than 20 years they were transmitted by cable, via Jupiter, Fla., but early in 1914 the cable was interrupted and since May 18, 1914, they have been transmitted by radio, first via Key West, later via Miami, Fla., and since November 20, 1922, via Jupiter. In November, 1922, a meteorological station was established at Great Inagua, one of the Bahama group. A representative of the Weather Bureau was sent there to assist in the installation of instruments and to instruct the observer. The observations are transmitted to Nassau, combined with the Nassau report, and forwarded via the naval radio station at Jupiter and thence by land line to Washington, D. C. The radio station operated by the Bahaman Government at Great Inagua is not sufficiently powerful to communicate directly with Nassau. Therefore, the reports are relayed through the Cuban radio station at Chaparra. At the request of the Weather Bureau arrangements are being made for the free handling of these reports by the Cuban Government.

Prior to the World War daily observations from a number of points in the Far East, including Siberia, and Russia, were obtained by cable. This service was discontinued during the war, and resumed, with the exception of Siberian and Russian reports, April 9, 1922, when, as a result of arrangements made with the director of the Philippine Weather Service, who collects observations from the Philippine group, China, Japan, and contiguous countries, a daily message is forwarded by naval radio from Manila to San Francisco and thence by land line to Washington. Reports from 12 places are included in this daily message.

Storm-warning work revolutionized.—Before radio communication reached a practicable stage and ships were equipped with radio apparatus the only means of warning vessels of storms was by furnishing masters with the warnings before they left port, and by the display of flags and lights on shore. Such storm signals were visible for a comparatively short distance and ships that departed before the warnings were issued and did not come within

visual range of the signals could not be warned. Radio communication has revolutionized the storm-warning service and now ships equipped with the necessary apparatus are as adequately served at sea as when in port.

The first application of radio communication to the storm-warning work was in July, 1902, when the Marconi Co., through its station on Nantucket Island, began to furnish liners of the Cunard Co. with forecasts issued by the Weather Bureau. In 1904, the broadcasting of storm and hurricane warnings became a regular service by naval radio stations and has continued in steadily increasing volume until the present time.

BROADCASTING OF WEATHER BULLETINS.

Inauguration of broadcasting of daily weather bulletins by naval radio stations.—On July 15, 1913, the broadcasting of daily weather bulletins was begun from the naval radio station at Arlington, Va., and Key West, Fla. The bulletins were broadcast at 10 p. m. and in two parts. The first part consisted of code letters and figures showing barometric pressures, wind direction and force at 8 p. m., 75th meridian time, at 8 places on the Atlantic and Gulf coasts and at Bermuda. The second part contained special forecasts of winds along the north, middle, and south Atlantic and the Gulf coasts a hundred miles or so offshore. Storm and hurricane warnings were included whenever issued.

A similar service was inaugurated for the Great Lakes on June 1, 1914, by broadcasts each evening from Arlington during the season of navigation, usually April 15 to December 15, inclusive. Beginning with April 15, 1917, the broadcasts for the Great Lakes were transferred to the naval radio station at Great Lakes, Ill.

At the suggestion of the Navy Department the broadcasting of a special bulletin from the naval radio station at Point Isabel, Tex., was inaugurated on August 27, 1920. This bulletin contains 8 p. m. reports from 8 places on the Gulf coast, also from Jamaica and Swan Island, and forecast and storm and hurricane warnings for the Gulf of Mexico, and the western portion of the Caribbean Sea.

On November 20, 1920, broadcasting of a bulletin for the special benefit of ships in the eastern Caribbean Sea and the southern Atlantic began from the naval radio station at San Juan, P. R. This bulletin is disseminated at 9 p. m., 75th meridian time, only during the hurricane season, June to November, inclusive, and contains reports from 10 observation stations in the West Indies and all hurricane warnings and advices pertaining to the southern Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. And on June 1, 1921, in response to demands from shipping interests the Arlington bulletin was made a twice-daily service, 10.30 a. m. and p. m. The number of coded reports in the a. m. bulletins was increased to 45, and included interior as well as coastal stations. This number of reports and a summary showing the location of cyclone and anticyclone centers and the direction of movement of storms enabled shipmasters to prepare comprehensive weather maps at sea on base maps specially prepared and furnished them for the purpose. An added feature of the expanded Arlington bulletin was upper-air observations from 5 aerological stations operated by the Navy Department, one by the Signal Corps, United States Army, and 3 by the United States Weather Bureau, and, for the special benefit of aviators, upper-air forecasts for 6 zones in which the country east of the Mississippi River is divided. This was the first radio bulletin ever broadcast in the United States for the benefit of aviators, and it was inaugurated at the special request

of the air services of the Army and Navy. On June 26, 1922, the Arlington p. m. major bulletin was made to conform with the one broadcast in the a. m.

On June 10, 1921, a localized broadcasting service was begun on the Atlantic and Gulf coasts and on the Great Lakes to supplement the major bulletins disseminated from the high-powered stations at Arlington, Key West, Point Isabel, San Juan, and Great Lakes. These local bulletins consist of wind and weather forecasts and storm warnings for limited areas, barometer readings, wind velocity and direction, and state of weather at near-by Weather Bureau stations and storm warnings issued in the afternoon. This service was designed for the benefit of coastwise ships not equipped to receive wave lengths as high as those used at the high-powered stations. The naval radio stations utilized in connection with this localized work were Portland, Me.; Boston, Mass.; New York, N. Y.; Philadelphia, Pa.; Baltimore, Md.; Norfolk, Va.; Charleston, S. C.; Savannah, Ga.; Jacksonville, Fla.; St. Augustine, Fla.; Miami, Fla.; St. Petersburg, Fla.; Pensacola, Fla.; New Orleans, La.; Galveston, Tex.; Point Isabel, Tex.; Alpena, Mich.; Buffalo, N. Y.; Cleveland, Ohio; Chicago, Ill.; and Duluth, Minn.; Guantánamo, Cuba; Port au Prince, Haiti; St. Thomas and St. Croix, Virgin Islands. Only hurricane warnings and advices are disseminated from the last five stations. On April 15, 1922, the local service from the stations on the Great Lakes was made twice daily by including an evening broadcast. Broadcasting was discontinued at Jacksonville, Fla., January 21, 1921; at St. Petersburg, Fla., on September 22, 1922; and at Miami, Fla., on November 20, 1922, due to the closing of these radio stations. On December 20, 1922, all the naval radio stations on the Lakes were placed in an inoperative status, and at this time (February 15, 1923) it appears unlikely that they will be placed in service during the 1923 season of navigation.

For the purpose of defining the forecasts contained in the bulletins broadcast from Arlington, Key West, San Juan, and Point Isabel, the ocean areas were divided into the following zones:

1. Atlantic coast, north of Sandy Hook.
2. Atlantic coast, Sandy Hook to Hatteras.
3. Atlantic coast, Hatteras to Florida Straits.
4. East Gulf of Mexico (east of longitude 90°).
5. West Gulf of Mexico (west of longitude 90°).
6. Caribbean Sea (west of longitude 73°) and the Windward Passage.

The forecasts and warnings for zones 1, 2, and 3 are included in the broadcasts from Arlington; zones 3, 4, 5, and 6 in those from Key West; and zones 4, 5, and 6 in those from Point Isabel.

On April 15, 1922, the bulletin broadcast from Great Lakes, Ill., was superseded by a much enlarged bulletin and was made a twice-daily service. It contains observations from 15 stations on the Great Lakes and 12 interior points, as well as upper air observations from 6 aerological stations operated by the Weather Bureau and 1 by the Signal Corps. In addition to weather forecasts for each of the Lakes and flying weather forecasts for four zones are included. These major bulletins are broadcast each morning and evening during the season of navigation on the Great Lakes at 10:45 o'clock, 75th meridian time. At first the bulletins were repeated by the Chicago radio station to Great Lakes for the general broadcast, but on May 19, 1922, the Navy Department began to operate the Great Lakes station by control from Chicago, thereby eliminating the repeat.

On March 15, 1922, a twice-daily major bulletin broadcast was begun from the naval radio station at San Francisco (Goat Island) at noon and 10:30 p. m., 75th meridian time. These broadcasts contain, respectively, 8 a. m. and 8 p. m. coded reports from 6 stations in Alaska, 26 stations on the Pacific coast and in the western States, and five reports from Canada; also upper air observations from five aerological stations, 3 of them operated by the Signal Corps, United States Army; 1 by the United States Navy, and 1 by the Weather Bureau. The several parts of the bulletin consist of a summary of barometric distribution at 8 a. m. and 8 p. m., over the western part of the United States, the Pacific Ocean, Alaska, and Canada, forecasts and storm warnings for the Pacific coast and flying weather forecasts for four zones comprising the Pacific coast States.

On the same date a supplemental localized service for the benefit of coastwise shipping was begun from the naval radio stations at Tatoosh Island, Wash.; North Head, Wash.; Eureka, Calif.; San Pedro, Calif.; and Dutch Harbor, Alaska. These local bulletins consist of wind and weather forecasts and warnings for limited areas, weather conditions, and barometric readings at specified stations, and advices concerning fog conditions in the Strait of San Juan de Fuca. These bulletins are broadcast each morning and evening and at intervals during the day.

Ships in the mid-Pacific forward their observations to the Weather Bureau at Honolulu, and forecasts and storm warnings are broadcast from the naval radio station at that point for the benefit of ships in that section of the Pacific, as well as a report of current weather conditions at Honolulu. These forecasts and reports are broadcast thrice daily. This service was begun on September 11, 1916.

Cooperation with United Fruit Co.—During the hurricane season of 1922 arrangements were made with the United Fruit Co., which for many years has been furnishing weather reports from its ships for broadcasting weather information and forecasts from its radio station on Swan Island for the benefit of shipping in the Caribbean Sea. This service began September 18, 1922. The bulletin is in two parts. The first part is in code and consists of weather observations taken at approximately 8 a. m., 75th meridian time, at Swan Island; Bluefields, Nicaragua; Belize, Honduras; Willemstadt, Curacao; San Juan, P. R.; Port au Prince, Haiti; Cienfuegos, Cuba; La Fe, Cuba; Kingston, Jamaica; and Turks Island, Bahamas. The second part consists of wind and weather forecasts for the Gulf of Mexico, the Caribbean Sea, and the Windward Passage, and all hurricane warnings and advices. The first part of the bulletin is broadcast only in the a. m. during the hurricane season; the second part is disseminated both morning and evening throughout the year. A feature of the service is the display of signals from the radio tower at Swan Island (a red pennant by day and red lantern by night). These signals, which began November 1, 1922, indicate that important weather information issued by the Weather Bureau regarding a hurricane or "norther" is in possession of the radio operator, which can be obtained by radio request or by boat-call ashore. The United Fruit Co. also permits ships of any nationality that fail to obtain the regular weather broadcasts to call the Swan Island station at any time for the latest weather forecasts.

Cooperation with Signal Corps.—The Signal Corps, United States Army, maintains radio stations at Bolling Field (D. C.), Aberdeen Proving Grounds (Md.), Camp Vail (N. J.), Mitchel Field (N. Y.), Langin Field (W. Va.),

McCook Field (Ohio), Langley Field (Va.), Selfridge Field (Mich.), and Chanute Field (Ill.), where weather observations are taken at 6:15 a. m., 7:15 a. m., 9 a. m., 11 a. m., and 3:15 p. m., and transmitted by radio for the benefit of aviators using the four model airways—Washington to Long Island, Washington to Dayton, Ohio, Washington to Hampton, Va., and Selfridge Field (near Mount Clemens, Mich.), to Chanute Field (Rantoul, Ill.). All of these observations are collected at Bolling Field and are promptly transmitted by telephone to the Weather Bureau office at Washington and are used by the forecasters in the issuance of flying-weather forecasts and advices to the Army aviators. This cooperative service began October 16, 1922.

RADIO WEATHER SERVICE FOR MARINE AND AGRICULTURAL INTERESTS.

Weather service for ships in midocean.—The need for and value of a forecasting service for the benefit of ships in midocean, and especially along the routes between the United States and Europe, long has been recognized, but there have been inherent difficulties which prevented the inauguration of a service of this character, chiefly the impracticability of collecting promptly and accurately current observations essential to such a system. For many years the Weather Bureau has been issuing twice-daily forecasts of wind and weather as far as the Grand Banks for the benefit of ships leaving North Atlantic ports, but it is apparent that a forecasting service for ships in midocean can not be conducted from any station located on continental shores and no island in the American-European lanes has a location advantageous to the purpose. The ideal arrangements would be one or more "floating islands"—ships anchored at selected positions—with trained meteorologists and forecasters aboard, to serve as collecting stations where weather reports would be charted and forecasts disseminated on fixed schedules. This is not possible of realization in the near future.

The most practical solution of the problem at the present time is the use of ships traveling the lanes with more or less regularity. The practicability of such a scheme already has been demonstrated by the French training ship *Jacques Cartier*. This ship has among its corps of instructors experienced meteorologists and forecasters, and on each of its voyages daily weather charts are prepared from weather reports furnished by ships within call and the weather reports and bulletins broadcast from the Arlington naval radio station and the Eiffel Tower. The forecasts are broadcast from the *Jacques Cartier* on regular daily schedules in both English and French.

The United States Weather Bureau is deeply interested in this pioneer project and is cooperating in the work. Maj. E. H. Bowie, the supervising forecaster of the Weather Bureau, took passage on the *Jacques Cartier* on its return voyage to France on February 11, 1923, for the purpose of assisting in the forecast work and observing the working of the scheme, especially in connection with the collection of observations by radio, and with the ultimate object of developing a program of service on American ships.

The dissemination by the Weather Bureau of weather information, forecasts, storm and hurricane warnings for the benefit of marine interests is believed to be the most complete and effective in the world. This valuable and indispensable service is accomplished in major part through radio stations operated by the Navy Department, and the Weather Bureau is greatly indebted to the officers connected with its radio operations for their cordial and sympathetic cooperation in this work.

Weather maps at sea.—The first weather map prepared at sea of which the Weather Bureau has a record was aboard the Red D Line S. S. *Caracas*, on December 1, 1905. The map was made by Mr. B. C. Kadel, an official of the Weather Bureau, when on his way from Willemstadt, Curacao, to New York. When off Cape Hatteras the weather was thick and the sea rough. The wireless operator, at the request of Mr. Kadel, obtained reports of barometric readings, state of weather, and wind direction and force from a number of ships and from a radio station on the Jersey coast and another at Hatteras. These reports were charted, and an accurate forecast was made that the *Caracas* would be out of the storm area by morning.

In August, 1908, Dr. P. Polis, director of the meteorological observatory at Aachen, Germany, made weather maps every day on board the S. S. *Kaiserin Augusta Victoria* during a passage from Germany to the United States. The reports were obtained by radio from United States coastal stations, from Europe, and from other ships.

The preparation of weather maps on ships is now common practice. The Weather Bureau furnishes masters special base maps for the purpose and the data are obtained from weather bulletins which it issues and broadcasts through naval radio stations. By means of the weather map storm centers are located and charted, and they provide a valuable aid in navigation.

Serving agriculturists by radio.—The act of Congress creating the Weather Bureau contains the expression, "for the benefit of agriculture, commerce, and navigation." Until recent years it was not possible to extend the benefits of the service effectively to agricultural interests, because a large proportion of the farmers could not be promptly supplied with weather forecasts and warnings of cold waves, heavy snows, frosts, etc., by ordinary means of dissemination. Extension of telephone lines into rural communities overcame a part of this difficulty, but large numbers of them could not be served thereby.

The Weather Bureau recognized the possibilities of radio in reaching agricultural interests and it began the dissemination of forecasts by this means as early as 1914. In January of that year arrangements were made for the broadcasting of forecasts by a station operated by the University of North Dakota, and nine amateur operators in that State received the forecasts in this way and made local distribution of them. In June, 1915, similar arrangements were made at Illiopolis, Ill.; Rock Island, Ill.; and Springfield, Ill. Sixteen amateurs, owning receiving sets, were known to obtain and distribute the forecasts.

On February 15, 1921, broadcasts of forecasts by radio stations operated by the Post Office Department in connection with its air mail service at Omaha, Nebr., and North Platte, Nebr., were begun, and a little later from its stations at Washington, D. C.; Bellefonte, Pa.; St. Louis, Mo.; Cheyenne, Wyo.; Rock Springs, Wyo.; and Salt Lake City, Utah. The service from St. Louis and Bellefonte was in operation only a few months.

The distribution of forecasts by radiotelegraphy to interior points served a valuable purpose, but it was of limited use to farmers, because few of them could take the time required to learn the telegraph code, and on that account they did not feel justified in installing receiving apparatus. However, the marvelous developments in radiotelephony during the past year or two changed the situation, and the Weather Bureau has kept abreast of these developments.

Broadcasting twice daily, at 10 a. m. and p. m., by radiotelegraph from the Arlington naval radio station of weather forecasts for each of the States comprised in the Washington forecast district, and on Wednesdays (April to October, inclusive) a summary of weather conditions as they affected crops during the preceding week, was inaugurated June 26, 1922. Similar services for the States in the Chicago, San Francisco, and New Orleans districts were begun June 20, 1922, August 23, 1922, and January 1, 1923, respectively.

Radiophone weather broadcasts.—The first systematic radiophone broadcasts of forecasts were made from the station operated by the University of Wisconsin beginning with January 3, 1921. Prior to that date and since October 1, 1916, broadcasts had been made therefrom by radiotelegraph. The next radiophone forecast distribution service was inaugurated on April 26, 1921, by the St. Louis (Mo.) University. This was the first station to disseminate river forecasts by this means.

On July 1, 1921, 12 radiophone stations in 7 States were broadcasting weather information, daily forecasts, river forecasts, crop information, cold-wave, frost, and other warnings. Since that time the work has been rapidly extended, and at the present time 140 radiotelephone stations in 39 States are engaged, as follows:

Alabama.....	3	Nebraska.....	7
Arkansas.....	1	New Jersey.....	1
California.....	11	New Mexico.....	3
Colorado.....	2	New York.....	8
District of Columbia.....	1	North Carolina.....	2
Florida.....	1	North Dakota.....	2
Georgia.....	3	Ohio.....	7
Territory of Hawaii.....	1	Oklahoma.....	3
Idaho.....	1	Oregon.....	3
Illinois.....	4	Pennsylvania.....	6
Indiana.....	3	Rhode Island.....	2
Iowa.....	6	South Carolina.....	1
Kansas.....	6	South Dakota.....	2
Kentucky.....	1	Tennessee.....	1
Maryland.....	1	Texas.....	13
Massachusetts.....	2	Utah.....	3
Michigan.....	3	Washington.....	2
Minnesota.....	6	Wisconsin.....	4
Missouri.....	8	Wyoming.....	3
Montana.....	3		

Practically all of the State forecast radio distribution work is conducted in cooperation with plants owned by individuals and commercial organizations, and at very little expense to the Weather Bureau. The forecasts and warnings are supplied them, as a rule, by telephone from field stations.

No broadcasting of weather reports and forecasts by radiophone were made by the Navy Department until February 15, 1923, on which date such service began from the Arlington station on 710 meters wave length. This service consists of the broadcasting, twice daily, at between 10:05 and 10:20 a. m. and p. m., of the forecasts for each of the States comprised in the Washington forecast district (all States east of the Mississippi River except Michigan, Illinois, and Indiana) and a general forecast for the district. Special warnings of cold waves, frosts, heavy snows, etc., issued in the afternoon and not included in the regular morning and evening broadcast, are disseminated between 3:45 and 4 p. m. Distant control operation is a feature of this service. The Weather Bureau office is connected by telephone with the radio operating room of the Navy Department, and the forecasts are announced from the forecast room of the Weather Bureau.

At a meeting of the Inter-departmental Advisory Committee on Governmental Radio Broadcasting held on February 2, 1923, it was decided to transfer all broadcasting formerly by the Post Office Department for the De-

partment of Agriculture, including the Weather Bureau, to the Navy Department. The Arlington radiophone service was inaugurated in accordance with this program. This affects the service performed by the Post Office radio stations at Washington, D. C.; Omaha, Nebr.; North Platte, Nebr.; Rock Springs, Wyo.; and Salt Lake City, Utah, and broadcasts of weather reports and forecasts from Washington were discontinued February 15, and from the other stations of the Post Office Department on March 1, 1923.

WEATHER BUREAU REPRESENTATION ON INTERNATIONAL AND OTHER RADIO BOARDS.

An international conference on wireless telegraphy was held in Berlin, June 28, 1906, on invitation extended by the German Government. The then Chief of the Weather Bureau, Prof. Willis L. Moore, was designated as the representative of the Department of Agriculture, but he was unable to attend. The transmission of meteorological observations evidently was not a serious subject of discussion and was not mentioned in the articles of agreement.

Professor Moore also represented the Department of Agriculture in the International Radio Telegraph Conference which was held in London during June and July, 1912. He attended the meetings and was signatory to the articles of that convention, which are now in effect. Meteorological observations and their transmission by coastal stations entered largely into the discussions, and Professor Moore took an active part in the formulation of Article XLV, which pertains to that feature of radio work.

In 1914 a committee of representatives of the several departments was appointed to draft regulations for radio telegraphy. Prof. A. J. Henry, of the Weather Bureau, was designated and served as the representative of the Department of Agriculture.

On October 21, 1915, an inter-departmental committee on radio legislation was formed. Prof. C. F. Marvin, Chief of the Weather Bureau, was appointed to represent the Department of Agriculture. This committee drafted a bill to regulate radio communication, which was introduced in the House of Representatives on December 22, 1916 (H. R. 19350) and in the Senate on December 19, 1916 (S. 7478).

On September 14, 1920, the American delegates to the preliminary conference on communication, to be held in Washington on October 8, 1920, invited Prof. C. F. Marvin to meet with them prior to the convocation of the conference for the purpose of discussing the subjects to be considered by the delegates to the radio protocol. The discussions of most interest to the Weather Bureau related to arrangements for the international exchange of meteorological reports by radio, and resulted in specific recommendations relating to collection of reports over extended areas by particular nations, who should become responsible for their redistribution to other cooperating nations; also to the procurement of a much greater number of meteorological reports from ships at sea. However, the delegates were disposed to regard these matters as foreign to the real purposes of the convention, and no action thereon was taken.

Early in 1921 the Secretary of State created an inter-departmental board to consider questions concerning communication, especially with reference to radio and telegraphic service for the Government. On May 17, 1921, Secretary Wallace nominated Professor Marvin as the representative of the Department of Agriculture.